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(54) [Title of the Invention] IMAGE DISPLAY APPARATUS AND MANUFACTURING METHOD THEREFOR

(57) [Abstract]

[Object] To precisely arrange support members at predetermined positions in an image display apparatus without increasing the manufacturing cost.

[Solving Means] A rear substrate 11 and a front substrate are disposed opposed to each other, a sidewall 13 is disposed on the peripheries of the substrates, and support members 14 are disposed between the rear substrate 11 and the front substrate, thereby constituting a vacuum envelope. The support members 14 are arranged in the vacuum envelope while a longitudinal tensile force is applied thereto. A lot of electron emitting elements are provided on the rear substrate 11 so as to oppose the front substrate, and a fluorescent screen is provided on the front substrate so as to oppose the rear substrate. The fluorescent screen emits light by

utilizing electron beams emitted from the electron emitting elements.

[Claims]

[Claim 1] An image display apparatus comprising:

a vacuum envelope including a rear substrate, a front substrate opposing the rear substrate, a sidewall provided on the peripheries of the rear substrate and the front substrate, and support members disposed between the rear substrate and the front substrate;

a lot of electron emitting elements provided on the rear substrate so as to oppose the front substrate; and

a fluorescent screen that is provided on the front substrate so as to oppose the rear substrate and that emits light by utilizing electron beams emitted from the electron emitting elements,

wherein the support members are disposed in the vacuum envelope in a state in which a longitudinal tensile force is applied thereto.

[Claim 2] The image display apparatus according to claim 1, wherein the support members are disposed in the vacuum envelope while being joined to a frame.

[Claim 3] The image display apparatus according to claim 2, wherein the frame is the sidewall.

[Claim 4] The image display apparatus according to claim 2, wherein the frame has grooves, and the support members are disposed while being fitted in the grooves.

[Claim 5] The image display apparatus according to claim 2, wherein a space-holding member is provided between the support members.

[Claim 6] The image display apparatus according to claim 5,

wherein the space-holding member is a comb-shaped plate.

[Claim 7] The image display apparatus according to claim 1, wherein the support members are joined to at least one of the rear substrate and the front substrate.

[Claim 8] A manufacturing method for an image display apparatus including a vacuum envelope having a rear substrate, a front substrate opposing the rear substrate, a sidewall provided on the peripheries of the rear substrate and the front substrate, and support members disposed between the rear substrate and the front substrate; a lot of electron emitting elements provided on the rear substrate so as to oppose the front substrate; and a fluorescent screen that is provided on the front substrate so as to oppose the rear substrate and that emits light by utilizing electron beams emitted from the electron emitting elements,

wherein the manufacturing method comprising the steps of:

applying a longitudinal tensile force to the support members; and

placing the support members in the vacuum envelope.

[Claim 9] The manufacturing method for the image display apparatus according to claim 8, wherein the support members to which the tensile force is applied are placed in the vacuum envelope.

[Claim 10] The manufacturing method for the image display apparatus according to claim 8, wherein the longitudinal tensile force is applied to the support members placed in the vacuum envelope.

[Claim 11] The manufacturing method for the image display

apparatus according to claim 8, wherein the tensile force is applied to the support members by pulling a frame to which the support members are joined.

[Claim 12] The manufacturing method for the image display apparatus according to claim 11, wherein the frame has grooves in which the support members are fitted.

[Claim 13] The manufacturing method for the image display apparatus according to claim 11, wherein the frame is positioned by a positioning portion provided in at least one of the rear substrate and the front substrate.

[Claim 14] The manufacturing method for the image display apparatus according to claim 8, further comprising the step of:

joining the support members to at least one of the rear substrate and the front substrate.

[Claim 15] The manufacturing method for the image display apparatus according to claim 14, wherein the support members are positioned by a positioning portion provided in at least one of the rear substrate and the front substrate.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention] The present invention relates to an image display apparatus having a lot of electron emitting elements, and a manufacturing method therefor.

[0002]

[Description of the Related Art] In recent years, there has been a demand for image display apparatuses for high-quality broadcasting or high-definition image display apparatuses, and

even higher screen display performance has been required. In order to meet these demands, it is necessary to flatten the screen surface and to increase the definition. Also, the weight and thickness must be reduced.

[0003] As an image display apparatus that meets the above-described demands, a flat image display apparatus shown in Fig. 11 is known. Fig. 11 (b) is an enlarged sectional view of a circled section in Fig. 11(a). In this image display apparatus, a silicon dioxide film 3 having a lot of cavities 2 is provided on a silicon substrate 1 serving as a rear substrate, and a gate electrode 4 made of, for example, molybdenum or niobium is provided on the silicon dioxide film 3. Conical electron emitting elements 5 made of, for example, molybdenum are provided on the silicon substrate 1 inside the cavities 2.

[0004] A front substrate formed of a transparent substrate 6, such as a glass substrate, is disposed parallel to and opposed to the silicon substrate 1 having the multiple electron emitting elements 5 with a predetermined space therebetween, thereby constituting a vacuum envelope 7. A fluorescent screen 8 is provided on a surface of the transparent substrate 6 opposing the electron emitting elements 5. Further, support members 9 are disposed between the silicon substrate 1 and the transparent substrate 6 to support an atmospheric load applied to the substrates 1 and 6.

[0005] In the image display apparatus having the above-described configuration, the fluorescent screen 8 is irradiated with electron beams emitted from the multiple electron emitting elements 5, and thereby emits light to form

an image. In this image display apparatus, the electron emitting elements 5 are sized in the order of micrometers, and the distance between the silicon substrate 1 and the transparent substrate 6 can be of the order of millimeters. For this reason, the resolution can be increased and the weight and thickness can be reduced, compared with cathode ray tubes that are now used in televisions or computer displays.

[0006]

[Problems to be Solved by the Invention] In the above-described image display apparatus, if the support members are seen from the front side, image degradation occurs. Therefore, it is necessary that the support members should be shaped like sufficiently thin columns or sufficiently thin plates such that they can be placed within non-luminous regions of the fluorescent screen. Moreover, a lot of support members of this type need to be arranged in order to support the atmospheric load.

[0007] However, it is quite difficult to precisely arrange a lot of small support members in the image display apparatus. Moreover, the yield drops, and the cost substantially increases. In view of these problems, various methods have been proposed to precisely arrange a lot of support members in the image display apparatus (for example, see Japanese Patent Laid-Open Nos. 8-7795, 9-92155, and 9-190786).

[0008] The arranging methods disclosed in the above publications are effective when the diagonal size of the image display apparatus is relatively small, for example, up to approximately 30 cm. However, it is difficult to precisely

arrange the support members in a large image display apparatus having a diagonal size of, for example, 80 cm or more. That is, in this large image display apparatus, the length of the support members need to be 40 cm or more.

[0009] In contrast, the support members are normally 1 to 2 mm in height and approximately 50 to 100 μm in thickness, and therefore, the support members are extremely elongated. The support members having such a shape are susceptible to bending and deflection. When the support members are held in the manufacturing process, it is difficult to maintain linearity of the support members. Therefore, in this case, the support members protrude from the non-luminous regions of the fluorescent screen.

[0010] When the support members are shortened or are shaped like sufficiently thin columns in order to avoid the above-described condition, the number of necessary support members is, for example, ten times or more of the number of support members shaped like long plates. Consequently, the defective fraction during the manufacturing process increases, and the manufacturing cost increases.

[0011] The present invention has been made to cope with these problems, and an object of the invention is to provide an image display apparatus in which support members can be precisely placed at predetermined positions without increasing the manufacturing cost, particularly when the image display apparatus is large, and a manufacturing method for the apparatus.

[0012]

[Means for Solving the Problems] An image display apparatus of the present invention includes a vacuum envelope having a rear substrate, a front substrate opposing the rear substrate, a sidewall provided on the peripheries of the rear substrate and the front substrate, and support members provided between the rear substrate and the front substrate; a lot of electron emitting elements provided on the rear substrate so as to oppose the front substrate; and a fluorescent screen that is provided on the front substrate so as to oppose the rear substrate and that emits light by utilizing electron beams emitted from the electron emitting elements. The support members are disposed in the vacuum envelope in a state in which a longitudinal tensile force is applied thereto.

[0013] The present invention provides a manufacturing method for an image display apparatus including a vacuum envelope having a rear substrate, a front substrate opposing the rear substrate, a sidewall provided on the peripheries of the rear substrate and the front substrate, and support members provided between the rear substrate and the front substrate; a lot of electron emitting elements provided on the rear substrate so as to oppose the front substrate; and a fluorescent screen that is provided on the front substrate so as to oppose the rear substrate and that emits light by utilizing electron beams emitted from the electron emitting elements. The manufacturing method includes the steps of applying a longitudinal tensile force to the support members; and placing the support members in the vacuum envelope.

[0014] In the image display apparatus and the manufacturing

method therefor according to the present invention, since the support members are placed in the vacuum envelope in a state in which a longitudinal tensile force is applied thereto, it is easy to maintain longitudinal linearity of the support members. Therefore, the support members are precisely placed at predetermined positions in the apparatus, that is, in non-luminous regions of the fluorescent screen, and image degradation due to positioning failure of the support members can be prevented.

[0015]

[Embodiments] Embodiments of the present invention will be described below with reference to the drawings.

[0016] Figs. 1, 2, and 3 are views showing the configuration of an image display apparatus according to a first embodiment of the present invention. An image display apparatus 10 shown in these figures includes a rear substrate 11 formed of various substrates, and a front substrate 12 formed of a transparent substrate such as a glass substrate. The rear substrate 11 and the front substrate 12 are disposed opposed to and parallel to each other with a predetermined space therebetween.

[0017] A sidewall 13 is provided on the peripheries of the rear substrate 11 and the front substrate 12 to hermetically seal the space therebetween, thereby defining a vacuum envelope. The degree of vacuum inside the vacuum envelope defined by the rear substrate 11, the front substrate 12, and the sidewall 13 is kept at, for example, 1×10^{-6} Torr or less. The rear substrate 11 and the front substrate 12 have a shape

of, for example, 760 mm $\times$ 460 mm $\times$ 2.8 mm (thickness).

[0018] A fluorescent screen 21 is provided on an inner surface of the front substrate 12, as shown in Fig. 2. The fluorescent screen 21 includes black-light absorbing layers 22 horizontally arranged in parallel and in stripes at predetermined intervals, fluorescent layers 23 provided between the black-light absorbing layers 22 and in stripes to emit light beams of three colors, red (R), green (G), and blue (B), and an aluminum layer (not shown) deposited on these layers, as shown in Fig. 4.

[0019] Plate-shaped support members 14 are arranged at predetermined intervals in the image display apparatus 10 to support an atmospheric load applied to the rear substrate 11 and the front substrate 12. The support members 14 have a shape of, for example, 420 mm $\times$ 2 mm $\times$ 100 μm (thickness). For example, these support members 14 are joined to the rear substrate 11 in a state in which a predetermined longitudinal tensile force is applied thereto. The support members 14 are sealed on the rear substrate 11 with fritted glass or the like.

[0020] That is, a longitudinal tensile stress lies inside the support members 14. Such application of the tensile force allows the support members 14 to have precise linearity in the longitudinal direction, and to be precisely sealed at predetermined positions without overlapping with electron emitting sections on the rear substrate 11. The support members 14 are in contact with the black-light absorbing layers 22 of the fluorescent screen 21.

[0021] Since the support members 14 have precise linearity in

the longitudinal direction, as described above, they will not be seen from the front side when an image is reproduced. That is, the support members 14 are located so as to precisely lie within non-luminous regions on the fluorescent screen (regions in which the black-light absorbing layers 22 are provided).

[0022] A conductive cathode layer 24 is provided on a front surface of the rear substrate 11, and an insulating film 26 having cavities 25 is provided on the conductive cathode layer 24. For example, the insulating film 26 is made of silicon dioxide. A gate electrode 27 made of, for example, molybdenum is provided on the insulating film 26. Electron emitting elements 28, for example, shaped like a microchip are provided on the conductive cathode layer 24 inside the cavities 25. These multiple electron emitting elements 28 constitute a cathode array. Lead wires for a cathode electrode, the gate electrode, and an anode voltage are sealed in through a seal surface 15 between the sidewall 13 and the rear substrate 11 (not shown).

[0023] In the image display apparatus 10 of this embodiment, video signals are input to the electron emitting elements 28 and the gate electrode 27 arranged in a simple matrix manner. With reference to the electron emitting elements 28, a gate voltage of +100 V is applied when the luminance is the maximum. A voltage of +10 kV is applied to the fluorescent screen 21. The magnitude of electron beams emitted from the electron emitting elements 28 is modulated by the voltage of the gate electrode 27. The electron beams cause the fluorescent screen 21 to emit light in order to form an image.

[0024] Since high voltage is applied to the fluorescent screen 21, as described above, glass plates for the rear substrate 11, the front substrate 12, the sidewall 13, and the support members 14 are made of a high-strain-point glass (e.g., PD200 (trade name) from Asahi Glass Co., Ltd. or CS27 (trade name) from Saint-Gobain Kabushiki Kaisha).

[0025] A manufacturing method for the above-described image display apparatus of the first embodiment will now be described.

[0026] First, a glass plate for a rear substrate 11 and a glass plate for a front substrate 12 are prepared by cutting a glass plate having a thickness of 2.8 mm to a size of 760 $\times$ 460 mm. Then, the glass plates are polished, for example, at three points (31 to 33) shown in Fig. 5, and the polished faces are used as positioning pads 31, 32, and 33.

[0027] That is, all below-described operations, application of a fluorescent screen 21, formation of a cathode array, positioning of support members 14, and assembly of the rear substrate 11 and the front substrate 12, are performed relative to the positioning pads 31 to 33. Therefore, when these positioning pads 31 to 33 are formed precisely, the positions of electron emitting elements 28, the positions of fluorescent layers 23 of the fluorescent screen 21, and the positional relationship among the support members 14 can be precisely determined in any process by using, for example, the same positioning jig 41 shown in Fig. 6.

[0028] Next, a fluorescent screen 21 is formed on the front substrate 12. A glass plate is prepared which has positioning

pads formed by polishing the same positions on the glass plate as those on the front substrate 12, and a fluorescent stripe pattern is formed on the glass plate by a plotter machine. The glass plate having the fluorescent stripe pattern and the glass plate for the front substrate 12 are loaded in the positioning jig, are placed on an exposure mount, and are subjected to exposure and development, thus forming the fluorescent screen 21.

[0029] After the front substrate 12 is temporarily taken out of the positioning jig, the glass plate for the rear substrate 11 is loaded in the same positioning jig with the positioning pads pressed against the jig, and a cathode array is formed by using the positioning jig as the reference. In order to form the cathode array, a matrix conductive cathode layer 24 is first formed on the glass plate, and an insulating film 26 made of silicon dioxide is formed on the conductive cathode layer 24 by, for example, thermal oxidation, CVD, or sputtering. Subsequently, a metal film of molybdenum or niobium for gate electrode formation is formed on the insulating film 26 by, for example, sputtering or electron-beam evaporation.

[0030] Next, a resist pattern shaped corresponding to a gate electrode to be formed is formed on the above-described metal film by lithography. The metal film is etched by wet etching or dry etching with the resist pattern used as a mask, thereby forming a gate electrode 27. Subsequently, the insulating film 26 is etched by wet etching or dry etching with the resist pattern and the gate electrode 27 as masks, thereby forming

cavities 25.

[0031] After the resist pattern is removed, electron beam evaporation is performed on the surface of the substrate from a direction inclined at a predetermined angle, and a separation layer of, for example, aluminum or nickel is formed on the gate electrode 27. Subsequently, a cathode forming material, such as molybdenum, is deposited on the surface of the substrate by electron beam evaporation from a perpendicular direction. As a result, electron emitting elements 28 are formed inside the cavities 25. The separation layer and the metal film provided thereon are removed by a lift-off method.

[0032] Then, support members 14 are sealed and joined to the rear substrate 11. First, fritted glass is applied on end faces of the support members 14, and is dried beforehand. Both ends of each support member 14 are chucked by a chucking machine, and are pulled in the longitudinal direction to apply a predetermined tensile force. Consequently, the long support member 14 can maintain good linearity in the longitudinal direction.

[0033] Then, the positioning jig in which the above-described rear substrate 11 is loaded is placed in the chucking machine, and the support members 14 are brought into contact with the rear substrate 11 by using the positioning jig as the reference. Since the support members 14 maintain good linearity in the longitudinal direction, as described above, the end faces of the support members 14 are precisely placed in contact with predetermined positions on the rear substrate

11. By then burning the support members 14 and the rear substrate 11, the support members 14 are sealed on the rear substrate 11 with the tensile stress lying therein.

[0034] Next, a sidewall 13 (shown in Fig. 7), on end faces of which fritted glass is applied and dried beforehand, is placed on the rear substrate 11, and the front substrate 12 is placed thereon. By placing each of the rear substrate 11 and the front substrate 12 with the three positioning pads pressed against the positioning jig, the positional relationship between the substrates can be determined precisely. It is satisfactory as long as the sidewall 13 can define the distance between the rear substrate 11 and the front substrate 12, and is not particularly required to have high positioning accuracy. The rear substrate 11, the sidewall 13, and the front substrate 12 thus placed are burnt, and are subjected to processes such as air exhaust, degassing, and aging, so that a target image display apparatus 10 is manufactured.

[0035] While the support members 14 are bonded to the rear substrate 11 by frit sealing in the above-described embodiment, the present invention is not limited to such a structure. For example, the support members 14 may be bonded to the sidewall 13 by frit sealing.

[0036] A second embodiment of the present invention will now be described.

[0037] Fig. 8 shows a state in which a front substrate 12 is removed from an image display apparatus according to the second embodiment of the present invention. In the second embodiment, sidewalls 13 are defined by long glass plates. On

the long glass plates that define the sidewalls 13, grooves 16 are formed beforehand at intervals corresponding to the positions of support members 14.

[0038] Longitudinal end faces of the support members 14 are fitted in the grooves 16, and are frit-sealed to form a support-member assembly 17 shown in Fig. 9. After fritted glass is applied and dried on end faces 13a of the sidewalls 13, the sidewalls 13 disposed at both ends of the support-member assembly 17 are chucked by a chucking machine, and are pulled in the longitudinal direction of the support members 14. Consequently, a plurality of long support members 14 can maintain good linearity in the longitudinal direction.

[0039] Subsequently, a positioning jig in which a rear substrate 11 is loaded is placed in the chucking machine, in a manner similar to that employed in the first embodiment, and the support-member assembly 17 is brought into contact with the rear substrate 11 with reference to the positioning jig. Since the support members 14 maintain good linearity in the longitudinal direction, as described above, end faces of the support members 14 are precisely placed in contact with predetermined positions on the rear substrate 11.

[0040] By then burning the support-member assembly 17 and the rear substrate 11, the support-member assembly 17 is sealed on the rear substrate 11 while the tensile stress lies in the support members 14. A front substrate 12 is sealed with reference to the positioning jig, in a manner similar to that employed in the first embodiment. Consequently, the rear substrate 11, the support members 14, and the front substrate

12 can be precisely arranged relative to one another.

[0041] While the support members 14 are sealed on the sidewalls 13 in the above-described embodiment, the present invention is not limited to this structure. A support-member assembly formed by bonding the support members 14 to a separately prepared frame may be sealed in the image display apparatus.

[0042] Fig. 10 shows a state in which a front substrate 12 is removed from an image display apparatus according to a third embodiment of the present invention. In the third embodiment, end faces of support members 14 are joined to separately prepared frames 18 by frit sealing. By pulling the frames 18, good linearity of a plurality of support members can be maintained in the longitudinal direction.

[0043] In the third embodiment, comb-shaped plates 19 serving as space-holding members are meshed with ends of a plurality of support members 14 to precisely define the intervals of the support members 14. The height of portions of the support members 14, in which the comb-shaped plates 19 are fitted, is 50 to 80% of the height of the center portions that support the rear substrate 11 and the front substrate 12. This makes it possible to precisely define the intervals of the support members 14 by means of the comb-shaped plates 19 while maintaining good linearity of the support members 14 in the longitudinal direction. Therefore, end faces of the support members 14 are more precisely placed in contact with predetermined positions on the rear substrate 11 and the front substrate 11.

[0044] Various modifications are possible without departing from the scope of the present invention. While the microchip-shaped electron emitting elements are used in the above-described embodiments, the present invention is not limited thereto, and the electron emitting elements may have any structure. For example, the electron emitting elements may be pn-type cold cathode elements or surface conductive electron emitting elements.

[0045]

[Advantages] As described above, according to the image display apparatus and the manufacturing method therefor of the present invention, since the support members are arranged in the vacuum envelope while a longitudinal tensile force is applied thereto, the positioning accuracy of the support members can be substantially increased without increasing the manufacturing cost. The positioning accuracy of the support members can be increased particularly in large image display apparatuses. Therefore, it is possible to prevent image degradation due to positioning failure of the support members, and to provide a high-quality image display apparatus with high reproducibility and at low cost.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is a perspective view showing the general configuration of an image display apparatus according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is a cross-sectional view showing the structure of the principal part of the image display apparatus shown in Fig. 1.

[Fig. 3] Fig. 3 is a view showing a state in which a front substrate is removed from the image display apparatus shown in Fig. 1.

[Fig. 4] Fig. 4 is a view of a fluorescent screen in the image display apparatus shown in Fig. 1.

[Fig. 5] Fig. 5 is a view showing a state in which positioning pads are formed in a manufacturing process for the image display apparatus shown in Fig. 1.

[Fig. 6] Fig. 6 is a view showing a substrate positioning state in the manufacturing process for the image display apparatus shown in Fig. 1.

[Fig. 7] Fig. 7 is a view of a sidewall in the image display apparatus shown in Fig. 1.

[Fig. 8] Fig. 8 is a view showing a state in which a front substrate is removed from an image display apparatus according to a second embodiment of the present invention.

[Fig. 9] Fig. 9 is a view showing the structure of a support-member assembly used in a manufacturing process for the image display apparatus shown in Fig. 8.

[Fig. 10] Fig. 10 is a view showing a state in which a front substrate is removed from an image display apparatus according to a third embodiment of the present invention.

[Fig. 11] Fig. 11 is a cross-sectional view schematically showing the structure of the principal part of a flat image display apparatus.

[Reference Numerals]

10: image display apparatus

11: rear substrate

12: front substrate

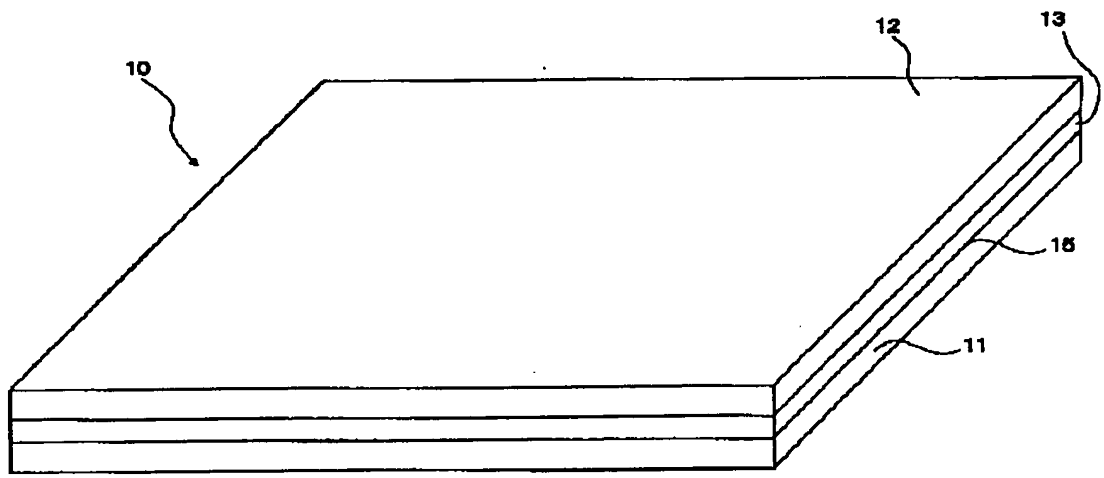
13: sidewall

14: support member

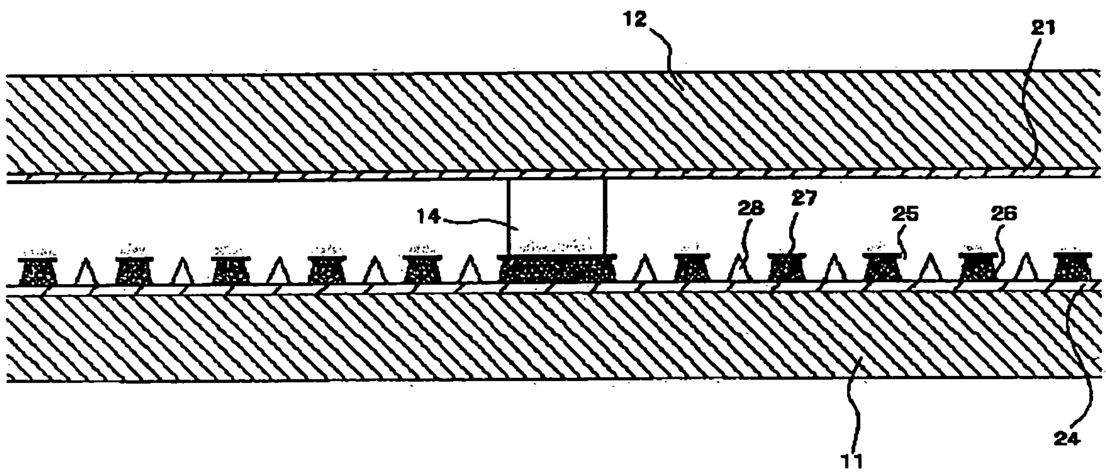
21: fluorescent screen

28: electron emitting element

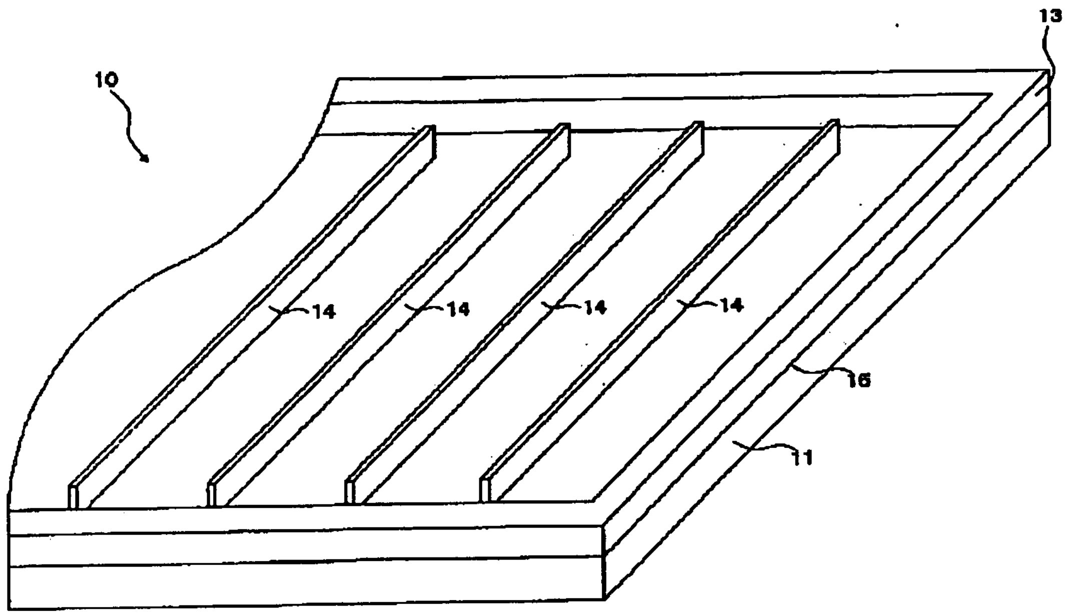
【Fig.1】



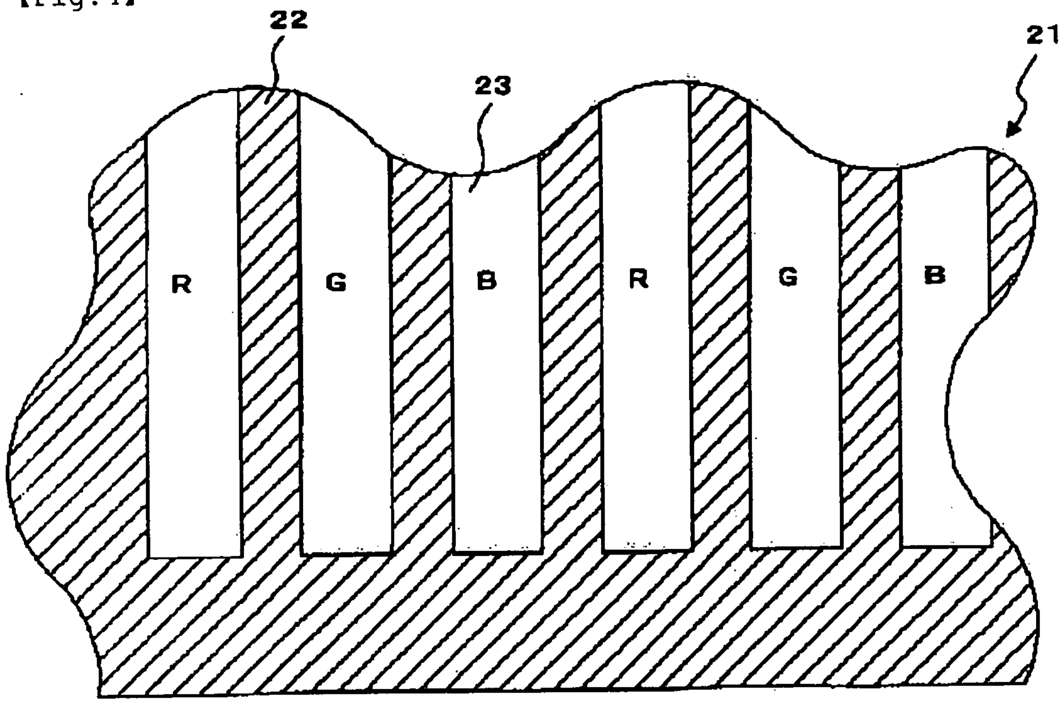
【Fig.2】



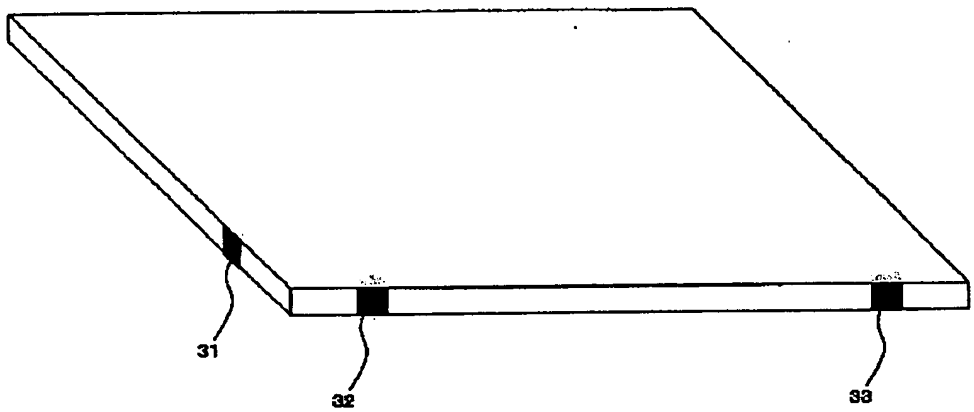
【Fig.3】



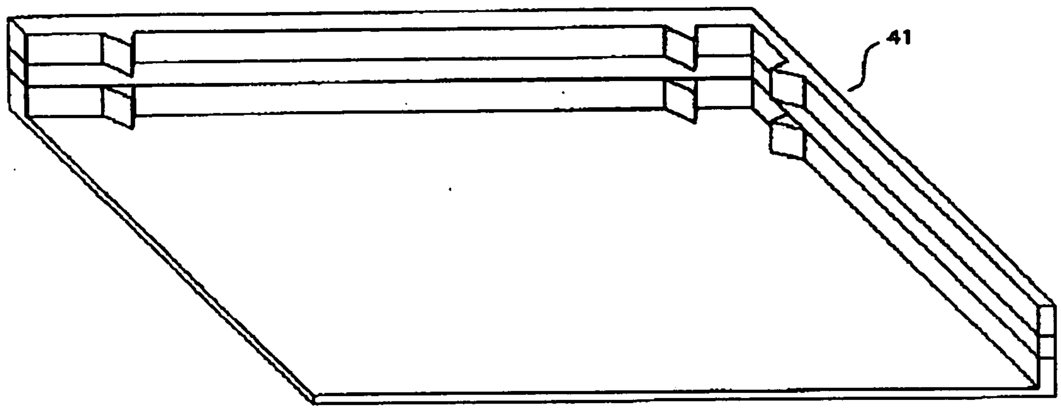
【Fig.4】



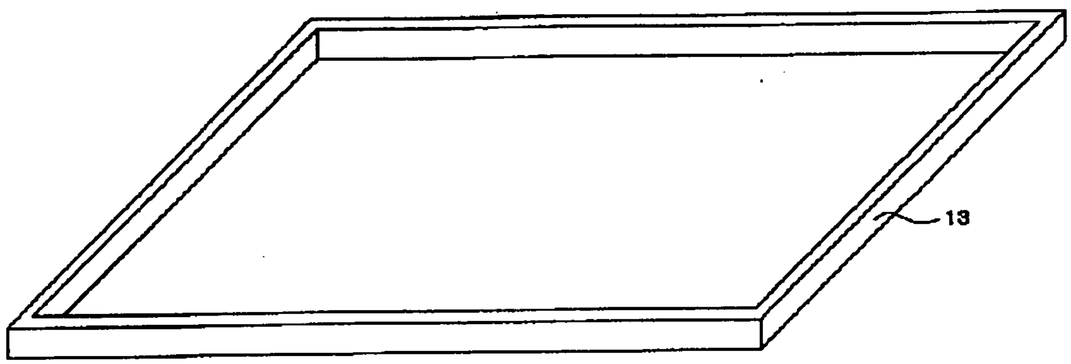
【Fig.5】



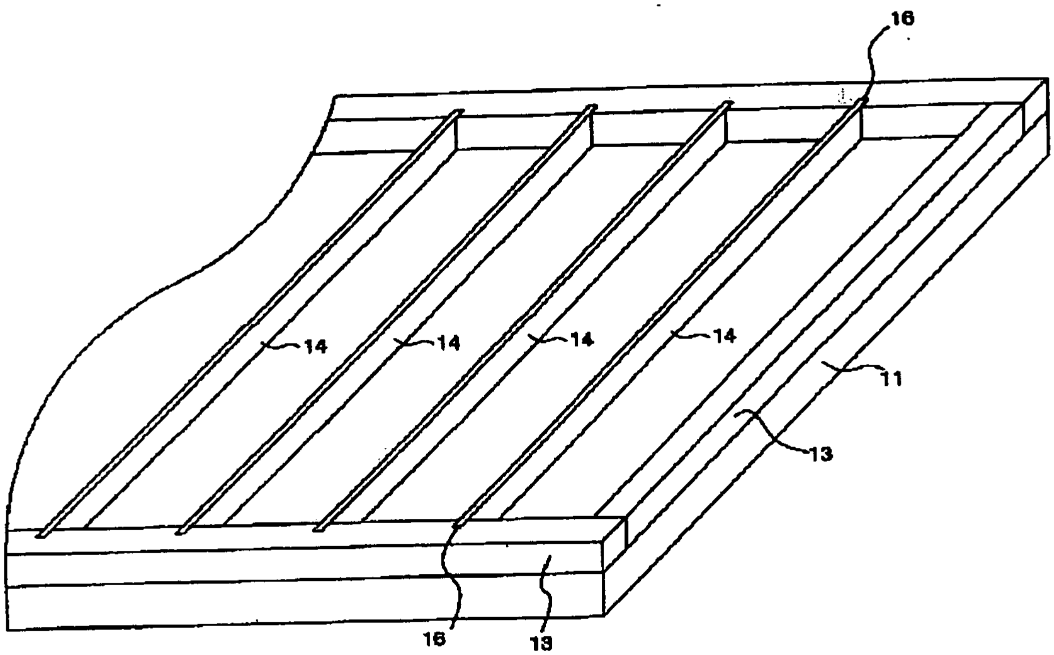
【Fig.6】



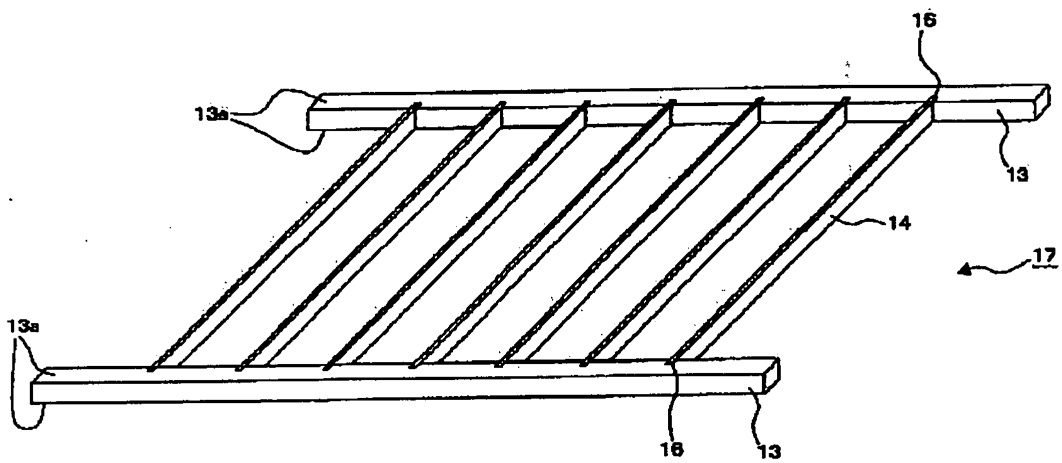
【Fig.7】



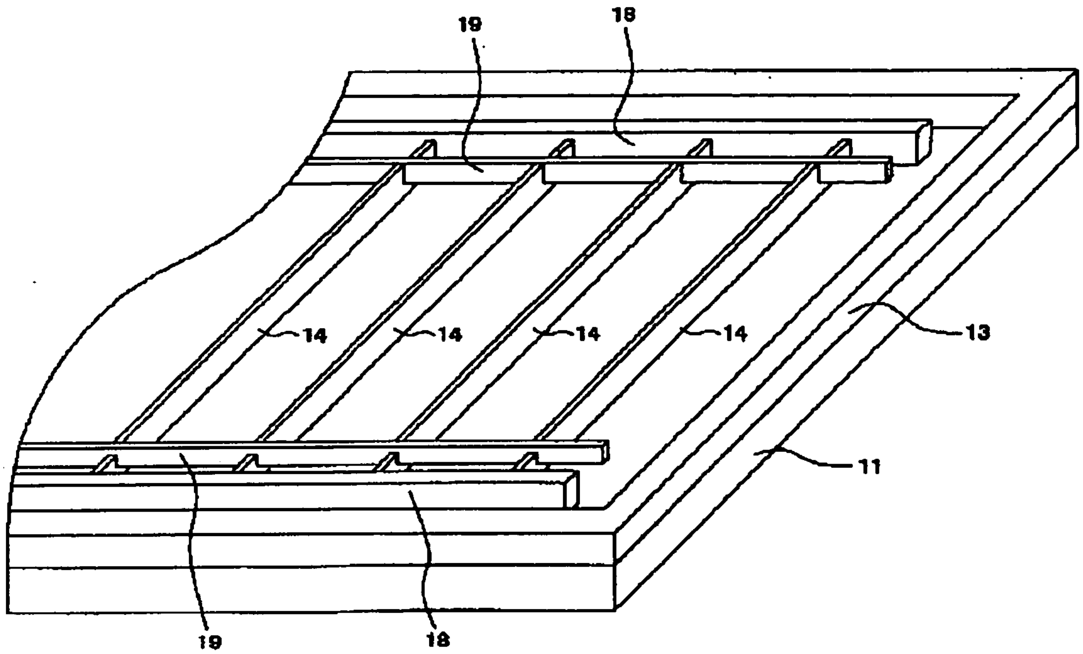
【Fig.8】



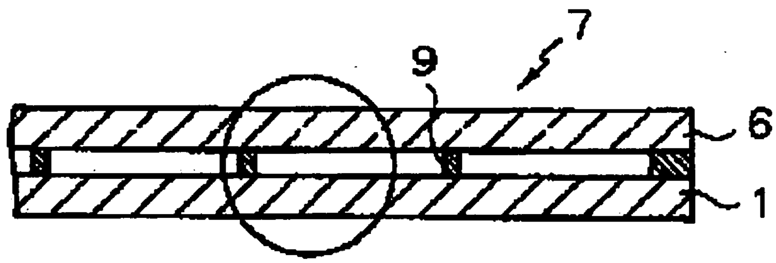
【Fig.9】



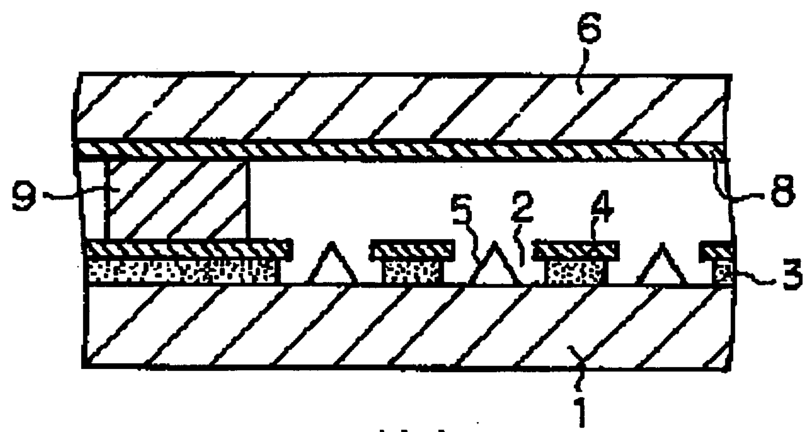
【Fig.10】



【Fig.11】



(a)



(b)